

BACKGROUND SOILS DATA SUMMARY REPORT

YERINGTON MINE SITE

Revision 1

March 9, 2009

PREPARED FOR:

Atlantic Richfield Company

4 CENTERPOINTE AVENUE
LA PALMA, CALIFORNIA 90623

PREPARED BY:

**BROWN AND
CALDWELL**

3264 Goni Rd, Suite 153
Carson City, Nevada 89706
(775) 883-411

TABLE OF CONTENTS

SECTION	PAGE
SECTION 1.0 INTRODUCTION	1
1.1 Report Organization.....	3
1.2 Data Quality Objectives.....	4
SECTION 2.0 SITE SETTING.....	7
2.1 Site Location and History	7
2.2 Physical Setting and Source Materials.....	8
2.3 Land Use	10
SECTION 3.0 FIELD INVESTIGATION	12
3.1 Sample Location Selection	12
3.2 Sampling Procedure	14
3.3 Soil Descriptions.....	15
3.4 EPA Split Samples.....	17
SECTION 4.0 ANALYTICAL DATA QUALITY CONTROL	18
4.1 Analytical Methods and Laboratories.....	18
4.2 Quality Assurance and Quality Control Procedures.....	20
4.2.1 Quality Assurance Objectives.....	20
4.2.2 Field Quality Control Samples	21
4.2.3 Data Review Procedures.....	22
4.3 Data Quality Summary and Analytical Completeness.....	25
SECTION 5.0 STATISTICAL ANALYSES.....	27
5.1 Data Characterization	27
5.2 Comparison of Concentrations in Sub-area A-1 and Sub-area A-2.....	28
5.2.1 Method Selection	30
5.2.2 Wilcoxon Rank Sum Test	30
5.2.3 Gehan Test	31
5.2.4 Results of Two-Sample Comparisons.....	32
5.3 Development of Background Concentration Limits	32
5.3.1 Estimation of the Mean and Standard Deviation.....	33
5.3.2 Upper Prediction Limits by the Chebyshev Method	34
5.3.3 Evaluation of Background Concentration Limits	35
SECTION 6.0 DATA INTERPRETATION AND USE	38
6.1 Geologic Interpretation	38
6.2 Comparison of Sub-Area Data.....	41
6.3 Use of Proposed Background Concentration Limits	43
SECTION 7.0 REFERENCES.....	46

TABLE OF CONTENTS - CONTINUED

LIST OF TABLES

Table 3-1	Relocated Sample
Table 3-2	Number of Samples per ASTM Soil Type
Table 3-3	EPA Split Samples
Table 4-1	Analyses and Methods
Table 4-2	Quality Control Field Samples
Table 4-3	Analytical Completeness by Method
Table 5-1	Summary Statistics and Results of Two-Sample Comparisons
Table 5-2	Background Statistics and Concentration Limits
Table 5-3	Summary of Background Concentration Limits

LIST OF FIGURES

Figure 1-1	Project Location
Figure 1-2	Yerington Mine Operable Units and Arimetco Facilities
Figure 1-3	Background Soil Sample Reference Areas
Figure 2-1	Background Reference Areas and Geologic Map
Figure 2-1a	Geologic Map
Figure 2-2	SCS Soil Classification Map
Figure 3-1	Background Soil Sample Locations

LIST OF APPENDICES

Appendix A.	Sample Location Photographs
Appendix B.	Field Logs
Appendix C.	ASTM Classifications and SCS Soil Descriptions
Appendix D.	Analytical Data, Moisture Contents and Comparison of Data (Compact Disk)
Appendix E.	Laboratory Reports and Data Validation Reports (Compact Disk)
Appendix F.	Individual Value Plots

ACRONYMS AND ABBREVIATIONS

ARC	Atlantic Richfield Company
ASTM	American Society for Testing Materials
BLM	Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DQO	Data Quality Objective
DSR	Data Summary Report
EPA	Environmental Protection Agency
ESI	Environmental Standards, Inc.
FD	Field Duplicate
GPS	Global Positioning System
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
LCS/LCSD	Lab Control Sample/Lab Control Sample Duplicate
IVP	Individual Value Plot
KM	Kaplan-Meier
MS/MSD	Matrix Spike/ Matrix Spike Duplicate
NDEP	Nevada Division of Environmental Protection
OHV	Off-Highway Vehicle
OU	Operable Unit
PARCC	Precision, Accuracy, Representativeness, Completeness and Comparability
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RI/FS	Remedial Investigation/Feasibility Study
RL	Reporting Limit
RPD	Relative Percent Difference
RSL	Regional Screening Level
SCS	Soil Conservation Service
SLERA	Screening Level Ecological Risk Assessments
SOW	Scope of Work
SSL	Soil Screening Level
TENORM	Technologically-Enhanced Naturally Occurring Radioactive Material
UAO	Unilateral Administrative Order
UPL	Upper Prediction Limits
VLT	Vat Leach Tails
WRS	Wilcoxon Rank Sum
bgs	below ground surface
mg/kg	milligram per kilogram
gpm	gallons per minute
pCi/g	picocurie per gram

EXECUTIVE SUMMARY

The results of an initial background soils investigation conducted by the Atlantic Richfield Company (ARC) in two reference areas adjacent to the Yerington Mine Site (Site) are presented in this updated Background Soils Data Summary Report (DSR; Revision 1). The DSR submitted to the U.S. Environmental Protection Agency –Region 9 (EPA) on September 8, 2008 required an update to correct an analytical laboratory error discovered by ARC in December 2008 for the non-radiological background soils data. Analytical data for metals presented in the September 8, 2008 DSR were not corrected for soil moisture content. All background soil moisture measurements were below 15 percent, with most soils exhibiting moisture values less than three percent.

Incorporation of the corrected chemical data provided the opportunity for ARC to re-calculate background concentration limits without using duplicate sample data, as suggested by EPA in their comments on the September 8, 2008 DSR. In general, the correction analyses resulted in slightly higher chemical concentrations in background soils, and correspondingly higher background concentration limits than the values presented in the September 8, 2008 DSR. The few results with lower background concentration limit values resulted from the elimination of the duplicate sample results from the statistical analysis.

The background soils investigation was conducted to establish natural or ambient concentrations of inorganic chemicals (metals and radiochemicals). Field sampling and analytical activities were conducted in accordance with the Background Soils Work Plan (Work Plan) approved by the EPA pursuant to the Anaconda/Yerington Mine Site Unilateral Administrative Order (UAO) for Initial Response Activities EPA Docket No. 9-2005-0011, dated March 31, 2005. Characterization of background soils at the Site followed EPA guidance. Background soils data will allow the remedial investigations and feasibility studies (RI/FS) for specific operable units (OUs) at the Site to be focused on chemicals associated with historic mining and mineral processing activities.

The reference areas for the initial background soils investigation contain alluvial fan materials derived from the Singatse Range that occur beneath the western portion of the Site. Two sub-areas (A-1 and A-2) were identified based on topography and mapped differences between bedrock source types for the fan materials. Sub-area A-1 consists of fan materials derived predominantly from rhyolite as flow tuffs. Sub-area A-2 consists of fan materials derived predominantly from rhyolite as flow tuffs and mineralized granitic rocks of the Yerington Batholith, and to a lesser extent, andesitic lava flows and limestone.

A total of 74 soil sample locations were selected, 37 from each sub-area, using a random selection method of points on a 500- by 500-foot grid (lands with residential or industrial developments or disturbances were excluded from the grid, as were bedrock outcrops). The simple random sampling method used in selecting sample locations is most useful when the population of interest is relatively homogeneous and without significant hotspots, as expected in the background soils reference areas. This sampling design provides statistically unbiased estimates of the mean, proportions and variability of the sample population.

Three soil horizons, identified by the U.S. Soil Conservation Service (SCS) for the alluvial fan materials within the reference areas, include: 1) a one-inch thick surface layer of gravelly sandy loam; 2) a subsurface horizon of brown gravelly clay from 1 to 9 inches bgs; and 3) a substratum horizon from 9 inches bgs to bedrock, consisting of very gravelly sandy loam. Samples were collected from the subsurface and substratum horizons at the consistent depths of 2 to 10 inches bgs for the shallow sample, and from 2 to 3 feet bgs for the deeper sample at each of the sample locations. The surface horizon was specifically excluded because it may have potentially been impacted by wind-blown dust and other anthropogenic sources.

No analytical data were rejected, although some data were qualified, and all data were found suitable for statistical analyses. Statistical methods used to develop background concentration limits (i.e., ‘thresholds’) followed EPA guidance, and used ProUCL software because it includes methods for: 1) analyzing background data, including the Chebyshev method for upper prediction limits (UPLs); and 2) analyzing censored data using the Kaplan-Meier method. Analysis of the background data indicated population differences between the two sub-areas (17 of the 24 chemicals subjected to hypothesis testing displayed statistically significant differences in concentrations between the two sub-areas), and background concentration limits were developed for each sub-area.

Although a preliminary review of the analytical data for the shallow and deep samples suggested two separate populations for some chemicals, risk assessments typically combine data from these depth ranges to calculate exposure point concentrations. Consequently, separate background concentration limits were not developed for shallow vs. deep sample populations. The data for shallow and deep sample intervals can be used to evaluate rock weathering and chemical transport within the soils profile, which is a different objective than using the data for risk assessment purposes.

The two sub-areas correspond with soils known to occur beneath specific Site operable units (OUs). Sub-area A-2 soils occur beneath the Process Areas (OU-3), the open pit and pit lake (OU-2) and the Waste Rock areas (OU-5). Sub-area A-1 soils occur beneath the Oxide Tailings (OU-6) and, potentially, a portion of the Evaporation Ponds and Sulfide Tailings (OU-4). Both sub-area A-1 and A-2 soils appear to occur beneath Arimetco Facilities (OU-8). Other soil types, mapped by the SCS, appear to occur beneath OU-4 and the Wabuska Drain (OU-7) and, potentially, beneath OU-6 and OU-8. The background concentration limits presented below were statistically derived for the two investigated sub-areas, and are applicable to OU-2, OU-3, OU-5 and OU-6. The characterization of other background (i.e., non-impacted) soil types that occur beneath the Site will be performed as part of future remedial investigation activities for the remaining OUs.

The background concentration limits summarized below, and additional, background concentration limits to be developed, will be used as screening levels to determine if naturally occurring metals are present at ambient concentrations on the Site. The characterization of background soils will: 1) provide the basis for a comparison of Site soils to determine areas impacted by historic mine operations; 2) support the development of remedial guidelines to manage impacted Site materials (i.e., impacted soils, tailings, waste rock, evaporation pond residues, etc.); and 3) support future risk assessment activities for the Site.

ARC anticipates that the background soils data presented in this updated DSR, and additional data to be collected during remedial investigations and from other background reference areas, will support the following RI/FS objectives:

- Chemicals that may have been released at the Site will be clearly identified to ensure that the RI/FS process is focused on the investigation of Site-related releases;
- The risk associated with background concentrations of inorganic chemicals will be calculated in the human health and ecological risk assessments to determine the difference between the risk associated with background and any releases from the Site (i.e., the ‘incremental risk’); and
- Remedial actions, such as EPA-approved presumptive remedies, and appropriate institutional controls will be limited only to chemicals with concentrations that are elevated above background as a result of a Site-related release.

Proposed Background Concentration Limits			
Constituent	Units	Sub-area A-1	Sub-area A-2
Aluminum	(mg/kg)	16,455	25,436
Antimony	(mg/kg)	0.94	1.8
Arsenic	(mg/kg)	13	17
Barium	(mg/kg)	171	310
Beryllium	(mg/kg)	1.0	1.3
Boron	(mg/kg)	24	21
Cadmium	(mg/kg)	0.32	0.35
Calcium	(mg/kg)	22,614	46,625
Chromium	(mg/kg)	11	19
Cobalt	(mg/kg)	12	15
Copper	(mg/kg)	58	285
Iron	(mg/kg)	19,502	28,465
Lead	(mg/kg)	11	13
Magnesium	(mg/kg)	6,314	9,889
Manganese	(mg/kg)	526	729
Mercury	(mg/kg)	0.031	0.050
Molybdenum	(mg/kg)	1.7	3.3
Nickel	(mg/kg)	12	18
Potassium	(mg/kg)	3,365	5,229
Radium-226	(pCi/g)	2.04	2.44
Radium-228	(pCi/g)	2.24	2.13
Selenium	(mg/kg)	0.80	0.87
Silver	(mg/kg)	0.54	0.58
Sodium	(mg/kg)	2,093	2,407
Thallium	(mg/kg)	0.61	0.60
Thorium	(mg/kg)	15	19
Uranium	(mg/kg)	2.9	4.1
Vanadium	(mg/kg)	57	65
Zinc	(mg/kg)	61	62

SECTION 1.0 INTRODUCTION

This revised Background Soils Data Summary Report (DSR) updates the results of the background soils investigation conducted by the Atlantic Richfield Company (ARC) in two reference areas adjacent to the Yerington Mine Site (Site), which was summarized in the initial DSR dated September 8, 2008. The background soils investigation described herein was conducted pursuant to the Administrative Order for Remedial Investigation and Feasibility Study (RI/FS), EPA Docket No. 9-2007-0005, issued by the Environmental Protection Agency – Region 9 (EPA) to ARC on January 12, 2007. The location of the Site is shown in Figure 1-1.

The field sampling activities, analytical results and statistical interpretation described in this DSR were performed to support future remedial investigations and remedial actions associated with existing conditions at the Site for the operable units (OUs) that overlie the investigated soil types. The following Site OUs were identified in the Order and attached Scope of Work (SOW):

- Site-Wide Groundwater (OU-1)
- Pit Lake (OU-2)
- Process Areas (OU-3)
- Evaporation Ponds and Sulfide Tailings (OU-4)
- Waste Rock Areas (OU-5)
- Oxide Tailings Areas (OU-6)
- Wabuska Drain (OU-7)
- Arimetco Facilities (OU-8)

The locations of these OUs are shown in Figure 1-2 (the Site-Wide Groundwater OU incorporates the entire Site and off-Site areas of previous and future groundwater investigations). Most of the OUs on the Site appear to overlie native soils with potentially different chemical characteristics (e.g., Evaporation Pond and Sulfide Tailings [OU-4]), while specific elements within OUs appear to overlie uniform native soil types (e.g., South Waste Rock Area [OU-5]).

A number of soil types that underlie Site OUs were not sampled as part of the background soils investigation described herein. Such potential background soils reference types would be sampled as part of future Site investigations where practicable. Specific background soil types that underlie individual OUs will be used as reference soils for those OUs in the RI/FS process.

Field sampling and analytical activities were conducted in accordance with the Background Soils Work Plan dated August 2, 2006 (Work Plan; Brown and Caldwell, 2006), which was approved by EPA on September 27, 2006 (EPA's approval included ARC's responses to EPA comments and points of clarification on a draft version of the Work Plan). Characterization of background soils followed EPA guidance (e.g., *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*; EPA, 2002a), including the following elements:

- Identification and randomized selection of sample locations in reference areas identified on the basis of geologic characteristics of bedrock source materials;
- Collection of soil samples from shallow and deep intervals at each location;
- Analysis of inorganic chemicals (herein termed 'chemicals'), composed of selected metals and radiochemicals, by an EPA-approved laboratory;
- Data validation and verification of laboratory analyses;
- Statistical analysis and interpretation of analytical results; and
- Recommendations for the future use of the background soils data and collection of additional background data from other reference areas.

Background soil sample locations were selected to represent materials that are naturally occurring (i.e., no samples are affected by anthropogenic activities). Sampling began in July 2007 following cultural resource surveys on lands managed by the U.S. Bureau of Land Management (BLM), required by the BLM for proposed surface disturbances associated with the investigation. Figure 1-3 depicts the background soils reference areas described in this DSR. Background soils data will support future decisions regarding remedial investigations associated with identified OUs at the Site, human health and ecological risk assessments, and the scoping and selection of appropriate remedial actions for the Site. The analytical results and statistical

interpretation presented in this DSR may be supplemented by additional background soils data resulting from OU-specific characterization activities pursuant to the SOW and/or sampling from other reference areas adjacent to the Site.

1.1 Report Organization

The remainder of Section 1.0 of this DSR presents modified data quality objectives (DQOs) for the background soils investigation. Section 2.0 provides background information on the geologic setting and history of the Site, including current and past land uses. A discussion of how the background soils data may be used in future remedial investigations and remedial actions, and the regulatory framework for such uses, is also presented in Section 2.0. Section 3.0 discusses the field investigation activities and procedures used in collection of the samples, including the field sampling objectives and field quality control procedures.

Variations in the planned and actual field implementation are provided in this section. Analytical laboratory analyses and data validation are discussed in Section 4.0 including analytical methods, detection limits and laboratory quality control procedures. The original data presented in the September 8, 2008 DSR were not corrected for soil moisture content, and the corrected data generally indicate slightly higher chemical concentrations in background soils than previously presented. A summary of data quality and usability and results of data validation review is also provided in Section 4.0.

Section 5.0 provides a summary of statistical methods applied to the data and the relevant statistical parameters identified. Section 6.0 provides an interpretation of the data and statistical results, a summary of the intended use of the data, and recommendations for additional reference areas where naturally occurring background soil samples may be collected to supplement the data presented in this DSR. Section 7.0 lists references cited in this DSR.

Appendix A of this DSR provides photographs of the sample locations in the two sub-areas. Appendix B provides the field logs for the soil sampling activities. Soil lithologic descriptions, including American Society for Testing Materials (ASTM) classifications and U.S. Soil

Conservation Service (SCS; 1984) soil types, are presented in Appendix C. Appendix D provides the background soils analytical data, including the moisture contents used to correct the original data set for metals, and compares the updated analytical results with the results presented in the September 8, 2008 DSR. Appendix E presents the laboratory reports and data validation reports, and Appendix F provides individual value plots for the analytical results from sub-areas A-1 and A-2.

1.2 Data Quality Objectives

Data quality objectives (DQOs) presented in the Work Plan were: 1) based on the systematic seven-step planning approach outlined in EPA guidance documents entitled *Guidance for the Data Quality Objective Process* (EPA, 1994), *Guidance on Systematic Planning Using the Data Quality Objective Process* (EPA, 2006), and the EPA background guidance document cited above (EPA, 2002a); and 2) established to design the field sampling and analysis plan for background soils that would yield technically defensible data to support remedial investigations, risk assessments and clean-up decisions for the Site. DQOs presented in Section 2.0 of the Work Plan, abbreviated and modified for use in this DSR, are provided below.

Step 1. State the Problem:

Background or pre-mining chemical concentrations in Site soils have not been determined, and background soils data will assist in determining where chemical releases from specific areas of the Site have occurred. Initial investigations in the Process Areas of the Site (Brown and Caldwell, 2005a and 2005b) indicated that historic ore processing operations at the Site resulted in localized releases of chemicals from process solutions and solids to soils and groundwater. Based on chemical concentrations observed in groundwater in other areas of the Site (e.g., evaporation ponds), ARC anticipates that other historic releases have impacted Site soils.

Background data from reference areas with naturally occurring concentrations of metals and radiochemicals in the same geologic and geochemical setting as Site soils are required to assess the nature and extent of potential contamination in Site soils and potential human health and ecological risks associated with the Site. Decisions related to OU-specific remedial

investigations, risk assessments and Site cleanup activities will, in part, be made on the basis of the range of chemical concentrations found in background soils.

Step 2. Identify the Decision

Prior to making Site decisions involving the use of background soils data, the adequacy of the data to support statistical analysis for a specific decision will be evaluated. The decision question is: Where on the Site are chemicals found as a result of a release from past mining and ore processing activities, and what are the release concentrations versus background conditions?

Step 3. Identify the Inputs to the Decision

Inputs will consist of: 1) analytical results from the background soil samples collected on the basis of soil types, bedrock source areas and depth; 2) statistical interpretations of the data; and 3) an understanding of the occurrence of background soils around the Site (i.e., soils not disturbed by mining and ore processing operations at the Site, and the relationship of these soils to geologically different source materials).

Step 4. Define the Boundaries of the Study

Spatial boundaries of the reference areas for the initial phase of background soil sampling were limited to areas with similar alluvial fan materials expected to underlie portions of the Site. Samples were collected from alluvial fan materials located topographically up-gradient of the Site (primarily to the west and, to a lesser extent, south of the Site) from two sub-areas based on bedrock geologic types that served as sources for the eroded fan materials. Sample locations within the two sub-areas were selected to avoid: 1) significant industrial, agricultural, residential or road disturbance; and 2) areas with the potential for Site-related effects such as surface runoff, fugitive dust accumulation, or mined ore or waste rock storage. Specifically, the two sub-areas correspond with soils known to occur beneath specific OU-2, OU-3, OU-5 and OU-6. Potentially, a portion of OU-4 may also be underlain by sub-area A-1.

The vertical boundary was established at a depth of up to three feet below ground surface (bgs). This boundary condition was developed in consultation with EPA. As remedial investigations

on the Site proceed according to the Order and attached SOW, additional reference areas for background samples may be identified, as described in Section 6.0 of this DSR.

Step 5. Develop a Decision Rule

The following decision rule will ultimately be used in comparing background and Site soils: “If Site soil concentrations exceed the background soil concentration statistic for a specific chemical, then that portion of the Site will assumed to have been impacted by mining or ore processing operations”. The decision rule would also include null and alternative hypotheses for one-sided statistical testing (EPA, 2002b).

Step 6. Specify the Limits on Decision Errors

When background soils data are compared to Site soils data for decisions regarding remedial investigations, risk assessments and remedial actions, the following two decision errors would be applied: 1) a Site soil concentration exceeds a background value when it does not; and 2) a Site soil concentration does not exceed a background value when, in fact, it does. A false rejection error (Type I) occurs when the decision maker erroneously rejects the null hypothesis. A false acceptance error (Type II) occurs when the null hypothesis is erroneously accepted. For the comparison of Site and background soils, a 10 percent error rate would be acceptable for both the Type I (α) and Type II (β) errors.

Step 7. Optimize the Design

The Work Plan was designed to meet these DQOs, including the following: 1) collection of samples from 37 locations within each of two geologically-defined sub-areas, and from shallow and deep intervals at each location to represent soils subject to variable physical and chemical processes; 2) documentation of soil lithology and physical characteristics during sampling; 3) analysis of collected samples for metals and radiochemicals observed in previous remedial investigations in the Process Areas of the Site; and 4) statistical interpretation of the analytical data to support the decision rule and identify potential decision errors.

SECTION 2.0 SITE SETTING

2.1 Site Location and History

The Site is located about one-half mile west and northwest of the City of Yerington in Lyon County, Nevada (Figure 1-1). Mining, milling and leaching operations for oxide and sulfide copper ores from the open pit in the southern portion of the Site were conducted between 1953 and 1978 by The Anaconda Company (Anaconda). Figure 1-2 depicts the locations of mine units identified on the Site, which generally coincide with the OUs defined in the SOW. Waste rock piles were constructed to the south and north of the open pit. Tailings impoundments and process solution evaporation ponds were constructed north of the Yerington Pit and the Process Areas, where the milling of oxide and sulfide ores took place.

Oxide ores were crushed and leached in vats with a dilute sulfuric acid solution that was produced from an on-Site acid plant (Acid Plant). The resulting copper sulfate solution was decanted and the remaining solids were placed in the tailings ponds. The copper sulfate solution was subjected to “iron laundering” in which the copper in solution is exchanged with iron, resulting in a copper precipitate. Residual solutions, containing elevated concentrations of iron and sulfate, were conveyed to evaporation ponds at a rate of about 700 gallons per minute (gpm) (Seitz et al., 1982).

Finely crushed sulfide ores were recovered using a flotation process with the addition of lime to achieve a neutral pH. Residual solids were then placed in the sulfide tailings ponds. During mining and ore processing operations conducted by Anaconda, the tailings deposition areas and associated evaporation ponds and containment ditches were progressively expanded to the north to accommodate the need for increased tailings capacity. Copper concentrates from the milling process were dried and shipped off-Site for smelting. Fine-grained tailings were transported to the ponds in slurry form, and the liquid fraction was recycled for use in further milling.

Seepage from the northernmost tailings pond was collected in a ditch system, and recycled along with the liquid fraction of the tailings fluid. The mineralogical characteristics of the oxide and sulfide ores and waste rock mined from the Yerington Pit, which contained naturally-occurring radioactive minerals, has resulted in the localized occurrence of technically enhanced naturally-occurring radioactive materials (TENORM) on the Site.

Arimetco acquired the property in 1988 from Mr. Don Tibbals, who had previously acquired the property in or about 1982 from Anaconda. Arimetco initiated leaching operations at five lined leach pads located around the Site (Figure 1-2) in the following sequence: Phase I/II (1990-1997); Phase II South (1992-early 1997, plus a few months in 1998); Phase III 4X (1995-1999); Phase IV-Slot (1996-1998); and Phase IV VLT (1995-1998). Some Arimetco leach pads and solution ponds were constructed on pre-existing waste rock and oxide tailings areas. Materials leached by Arimetco include previously deposited waste rock north of the Yerington Pit, VLT materials and ore from the MacArthur Pit, located northwest of the Site.

Arimetco constructed and operated an electro-winning plant with associated solution ponds located south of the former mill area (Figure 1-2). Arimetco ceased mining new ore and leaching operations in November 1998, and continued to recover copper from the heaps until November 1999 (EPA, 2007a). Arimetco filed for bankruptcy in 1998 and abandoned the Site in 2000. From 2000 through 2004, the Nevada Division of Environmental Protection (NDEP) managed heap process fluids by re-circulation and evaporation. In 2005, ARC was required by EPA to assume responsibility for fluid management operations at the Site pursuant to the Interim Response Actions UAO issued to ARC by EPA (2005a).

2.2 Physical Setting and Source Materials

The Site is located on the west side of Mason Valley in west-central Nevada (Figure 1-1). Mason Valley is surrounded by uplifted mountain ranges within the Basin and Range physiographic province. Mason Valley is bordered by the Singatse Range to the west, the Desert Mountains to the north, and the Wassuk Range to the east.

The Site is located in a high desert environment characterized by an arid climate. Monthly average temperatures range from 33.3° F in December to 73.7° F in July. Annual average rainfall for the City of Yerington is only 5.3 inches per year, with lowest rainfall occurring between July and September (WRCC, 2007). Wind speed and direction at the Site are variable as a result of natural conditions and variable topographic features created by surface mining operations. Meteorological data collected since 2002 indicate that the dominant wind directions are to the north and the northeast (Brown and Caldwell, 2008). The Walker River flows northerly and northeasterly between the Site and the City of Yerington (Figures 1-1 and 1-2).

Geologic Setting

Mason Valley occupies a structural graben (i.e., down-dropped faulted basin) typical of basin-and-range topography. The Singatse Range, located immediately south and west of the Site, is an uplifted mountain block. The Site is located on the distal edge of a large alluvial fan developed during uplift of the Singatse Range (the alluvial fan materials were derived from erosion of bedrock outcrops along the eastern margin of the range). Mining and ore processing activities at the Site have resulted in modifications to the natural, pre-mining topography including a large open pit (occupied by the pit lake), waste rock and leached ore piles, evaporation and tailings ponds, and building and process facilities.

The mountain blocks are primarily composed of granitic, metamorphic and volcanic rocks with minor occurrences of limestone outcrops. The Singatse Range has been subject to regional metals mineralization, as evidenced by the large copper porphyry ore deposit at the Yerington Mine and other nearby mines (e.g., MacArthur Mine and Bear copper porphyry deposit underlying the sulfide tailings at the Site). Proffett and Dilles (1984) published a geologic map (reproduced as Figure 2-1 of this DSR) of the Yerington District that describes the geology and mineralization of the Yerington District. As part of the Yerington District, the Site and immediately surrounding area are characterized by surface expressions of base and precious metals mineralization, and associated hydrothermal alteration, of bedrock outcrops of granitic and volcanic rocks.

Alluvial Fan Materials

SCS (1984) soils map for Lyon County, Nevada includes the area surrounding the Site. The following major soils types for the alluvial fan materials immediately west of the Site were mapped by the SCS: Patna fine sand (511); Rawe gravelly sandy loam (551); and the Rawe-Malpais association (553). These and other soil types with more limited surface exposure around the Site are described in Appendix C. Figure 2-2 shows the SCS soil types in the area of the Site.

The distribution of chemicals in the fan materials depends primarily on the mineralogy of the source (i.e., parent) rock from which the soil was derived. Therefore, the natural geochemical relationships that exist in the source rock are usually reflected in nearby or down-gradient soils. Additionally, concentrations of naturally occurring chemicals usually are related closely to soil type.

Soils that contain abundant gravel and coarse sands tend to have geochemical characteristics more closely related to the parent rock. Finer soils with abundant silt and clay have undergone more chemical and physical weathering and, therefore, will exhibit greater differences relative to the source rock. Clay and silt can also act as a barrier to mobilized chemicals and can therefore have higher concentrations of mobile constituents as they tend to accumulate in these layers.

The reference areas for the soils background investigation at the Site include the two sub-areas described in Section 3.0, defined on the basis of the up-gradient bedrock source materials exposed in the Singatse Range. The sub-areas are separated by the Mickey Pass Canyon drainage, a natural boundary between the two sub-areas. Although obscured by surface disturbances, this boundary likely extends through the Site and terminates against the fluvial sedimentary deposits of the Walker River (Figures 2-1 and 2-2).

2.3 Land Use

The majority of the reference areas occur on land managed by the BLM. The primary current use of the lands is recreational, with a number of dirt roads and jeep trails that are used by off-

highway vehicles (OHVs). There is no evidence that the area is currently used for livestock grazing, as there are no livestock fences, although the presence of a historic homestead at the north end of the study area may indicate historic ranching and agricultural activities.

Historical mining and prospecting operations have occurred around the perimeter, and within the reference areas, as evidenced by several “cat scrapes” and prospect pits. A currently inactive gravel mine and asphalt batch plant exist at the southern end of the reference areas, which were in operation as recently as two years previous to the background soils investigation conducted by ARC. The specific area of the gravel mine and asphalt batch plant has been reclaimed and all equipment and buildings have been removed. A low-density residential area exists at the northern end of the reference areas, and a medium-density residential area (the community of Weed Heights) exists in the central portion of the reference areas. All known disturbed areas, including residential, mining, prospecting and industrial, were excluded from the reference areas to ensure that soils included in the investigation represented undisturbed native soils.

SECTION 3.0

FIELD INVESTIGATION

3.1 Sample Location Selection

The reference areas (Figure 1-3) selected for the background soils investigation contains alluvial fan materials derived from erosion of the Singatse Range that, based on the SCS soil information provided in Figure 2-2, are the same alluvial fan materials that underlie specific portions of the Site (e.g., native soils beneath OU-2, OU-3, OU-5 and OU-6). The reference areas include two sub-areas (A-1 and A-2) based on topography and mapped differences between bedrock sources for the fan materials (Figure 2-1). Sub-area A-1 occurs west and north of the Site, and consists of fan materials derived predominantly from the Mickey Pass Tuff (rhyolite ash flow tuff). Sub-area A-1 is bounded to the south by the Mickey Pass Canyon drainage. Sub-area A-2 occurs along the southwest margin of the Site, and is composed of alluvial fan deposits and soils predominantly derived from a mixture of Mickey Pass Tuff (approximately 40 percent) and granitic rocks of the Yerington Batholith (approximately 40 percent). Additional bedrock in this sub-area includes andesitic lava flows and limestone (approximately 10 percent each).

A total of 74 locations were selected, 37 from each sub-area (plus duplicates), using a random selection method of points on a 500- by 500-foot grid overlying the reference areas (Figure 3-1). Lands with residential or industrial developments or disturbances were excluded from the grid of possible sample locations, as were areas of bedrock outcrops. The simple random sampling method used in selecting sample locations is most useful when the population of interest is relatively homogeneous and without significant hotspots, as was expected in the background soils reference areas. This sampling design provides statistically unbiased estimates of the mean, proportions and variability of the sample population.

Three soil horizons, identified by the SCS for the alluvial fan materials within the reference areas, include: 1) a one-inch thick surface layer of gravelly sandy loam; 2) a subsurface horizon of brown gravelly clay from 1 to 9 inches bgs; and 3) a substratum horizon from 9 inches bgs to

bedrock, consisting of very gravelly sandy loam (SCS, 1984). Samples were collected from the subsurface and substratum horizons at the consistent depths of 2 to 10 inches bgs for the shallow sample, and from 2 to 3 feet bgs for the deeper sample at each of the sample locations. The surface horizon was specifically excluded because it may have potentially been impacted by wind-blown dust and other anthropogenic sources.

Each sampling location was identified in the field using a Garmin Trex handheld global positioning system (GPS), and marked using a two foot wooden stake several months prior to the sampling activity. The Garmin GPS was then used by the sampling personnel to navigate back to the planned sample location until the stake was physically located, and the sample was collected at the original staked location. In the event that the original staked location was inappropriate (e.g., inaccessible or unsafe for the field team to access with the backhoe, the area exhibited surface disturbances such as road or construction activities, or the sample location occurred on a privately owned land parcel for which access had not been granted), the sampling location was moved a minimal distance to avoid the obstacle and was described in the field notes.

Table 3-1. Relocated Samples		
Location Designation	Approximate Distance and Direction Moved	Reason
BGS-A-1-01	180' W	Stay off private property, no access agreement
BGS-A-1-05	150' E	Remain outside marked archeological site boundary
BGS-A-1-07	100' W	Stay off private property, no access agreement
BGS-A-1-08	100' W	Stay off private property, no access agreement
BGS-A-1-37	150' S	Safety concern, original location on steep slope
BGS-A-2-66	70' N	Avoid area disturbed by gravel pit operation
BGS-A-2-70	50' W	Stay off private property, no access agreement
BGS-A-2-71	350' W	Stay off private property and avoid rock outcrops

3.2 Sampling Procedure

Each sample location was excavated by backhoe to form a pit with sloped walls on three sides and a vertical wall on the fourth side for sampling. The dimensions of the pit were approximately 6 to 8 feet long and 4 to 6 feet wide and the depth was generally no more than 6 inches deeper than the maximum sample depth of 36 inches. Photographs of the trenches at each sample location are provided in Appendix A

Samples were collected as “vertical channel samples” over the desired sample interval, as measured by vertical distance from the ground surface of the excavated area. The channel sample was collected using a disposable plastic scoop or reusable steel rock pick to loosen the soil in a vertical groove. The sample was collected in a disposable ziplock bag held underneath the channel. Care was taken to push any loose soil and vegetation away from the top of the excavation to minimize surface materials from falling into the sample collection bag. Care was also taken to try to gather an equal volume of soil from all parts of the sample column to avoid selective sampling of any one vertical interval within the channel. The exception to this included intervals where a large boulder or very rocky materials were encountered so that rocky materials were avoided and finer grained materials were collected. Pebbles or rocks greater than one-half inch in maximum dimension, and organic materials (e.g. roots, leaves), were removed from the sample by picking them out by hand.

Samples were homogenized by agitating and mixing the contents of the ziplock bag for at least one minute by tumbling the sealed bag end over end. The homogenized sample was then distributed to the individual laboratory-supplied sample containers. Duplicate and split samples were distributed out of a single homogenized sample bag.

As each location was sampled, its position was mapped using a Trimball GeoXT GPS unit with an accuracy of one meter or less. Typically, the GPS unit was given 5 or more minutes to track in-range satellites, which provides an accuracy of approximately +/- 30 cm horizontally. These

surveyed locations are shown in Figure 3-2 and represent actual sample locations. Subsequently, the excavation was filled in, the surface smoothed back to natural topography, and the marking stake was replaced in the backfilled soil to designate the sample location.

3.3 Soil Descriptions

Soils at each sample location were described by field sampling personnel and recorded in the field log books, provided in Appendix B. Each sample was classified using the American Society for Testing Materials (ASTM) D2488 Standard, which recognizes 15 soil groups and uses names and letter symbols to distinguish between these groups. Coarse grained soils are divided into gravels (G) and sands (S), which are sub-divided into four secondary groups. Fine grained soils are divided into silts (M) and clays (C). Soils are also classified according to their plasticity and grading. Plastic soils are able to change shape under the influence of applied stress and to retain the shape once the stress is removed. Soils are referred to either low (L) or high (H) plasticity. The grading of a soil sample refers to the particle size distribution of the sample. A well graded (W) sand or gravel has a wide range of particle sizes and substantial amounts of particles sized between the coarsest and finest grains. A poorly graded (P) sand or gravel consists of predominately uniform grain sizes, but can include multiple grain sizes with intermediate sizes absent.

Soils in the reference areas were described as predominantly sand or gravel, with visible rock clasts sourced from the topographically up-gradient bedrock outcrops. The most common soil type was determined to be a well-graded sand (SW), which is described in the field notes as a silty-sand with gravels and a range of particle sizes. This soil type is more common in sub-area A-1 and is also more frequently described in the shallow interval. A poorly-graded sand (SP) was also identified in the reference areas, and is generally described as an uncompacted fine to coarse grained sand with minor gravel and even less silt. This soil type is more likely to occur in the shallow interval, and appears to result from recent weathering activities (e.g., ephemeral surface runoff conditions).

Soils with coarser rock and gravel content (GW and GP) were more commonly found in sub-area A-2 and were also more common in the deep interval. Approximately two thirds of the deep soil samples in sub-area A-2 were described as gravels, which can be explained by the greater occurrence of rock outcrops in the area and therefore a closer proximity to the underlying bedrock source. In fact, several sample locations encountered decomposed bedrock within the excavation. Table 3-2 summarizes the number of samples per soil type by location and depth.

Table 3-2. Number of Samples per ASTM Soil Type				
Interval	Sand		Gravel	
	Well-graded (SW)	Poorly-graded (SP)	Well-graded (GW)	Poorly-graded (GP)
Area 1				
shallow	17	11	8	1
deep	14	8	8	7
Area 2				
shallow	13	13	10	1
deep	9	3	20	5
TOTAL	53	35	46	14

Occurrences of caliche, a white calcium carbonate mineral, were commonly observed in the excavated soils from both sub-areas at depths typically starting between one to three feet below the surface. Caliche occurrences were generally weak and dispersed throughout the pore space as a coating on medium to coarse particles within the soil and concentrated in plant roots. In several locations the caliche occurred as distinct horizons typically less than six inches in thickness which were discontinuous and not strongly cemented. In an arid environment, caliche generally forms when rainwater quickly percolates into the ground through porous soils, and then rises towards the surface dries. Dissolved minerals from the lower horizons are transported upward, and deposited within the shallower sections. Soil lithology and ASTM classifications are summarized in Appendix C, which also includes a description of the SCS soil types shown in Figure 2-2.

3.4 EPA Split Samples

Split samples were collected on behalf of EPA by Mr. Doug Herlocker of TetraTech/EMI at eight locations, four from each sub-area, resulting in representation of 10 percent of all locations sampled during the sampling event. The locations for split samples were selected by EPA prior to the start of sampling based on a wide-spread distribution of sample locations. Split samples were collected from both the shallow and deep sample intervals at each location, and were collected in the same manner as duplicate samples in which one large volume was collected and homogenized in the disposable ziplock bag and then distributed to sample containers for ARC's and EPA's samples. Table 3-3 lists the locations from which EPA split samples were collected.

Table 3-3. EPA Split Samples	
Sub-Area	Sample Location
A-1	BGS-A-1-03 (EPA duplicate)
	BGS-A-1-13
	BGS-A-1-09
	BGS-A-1-20
A-2	BGS-A-2-42
	BGS-A-2-52 (EPA duplicate)
	BGS-A-2-62
	BGS-A-2-64

SECTION 4.0

ANALYTICAL DATA QUALITY CONTROL

All samples were analyzed by TestAmerica laboratories according to the requirements specified in the Work Plan, and as described below. Analytical data, including original laboratory reports, are provided in Appendix D and data review and validation reports are provided in Appendix E on compact disc. Appendix D contains a hard copy and simplified Excel spreadsheet of the data (D-1), and a more extensive Excel spreadsheet (D-2) that includes additional information including quality control annotations. Non-detects are presented as “<X” in Table D-1, where X is the detection limit. Appendix D-3 contains Excel spreadsheets that provide moisture contents for the soil samples and a comparison of analytical results presented in the September 8, 2008 DSR with the results corrected for soil moisture content. Sample designations were described in Section 3.0 of this DSR. Laboratory and data validation reports are provided in Appendix E.

4.1 Analytical Methods and Laboratories

TestAmerica Laboratories was used to complete the analysis of soil samples at the following three locations: 1) TestAmerica Irvine (previously Del Mar Analytical) for the metals analysis, 2) TestAmerica Richland (previously STL Richland) for radiological analysis (radium-226 and -228), and 3) TestAmerica St. Louis (previously STL St. Louis) for uranium and thorium. The Irvine and Richland labs have been used for previous analytical work at the Site and have undergone ARC’s laboratory evaluation and auditing procedure. The TestAmerica St. Louis lab was identified as best location to analyze uranium and thorium by the 6020 method (ICP-MS).

All TestAmerica lab locations were provided a copy of the Site-specific Quality Assurance Project Plan (QAPP; Environmental Standards, Inc. and Brown and Caldwell, 2008; Revision 4), and indicated that they were able to meet the requirements of the QAPP. If the labs could not comply with specific aspects of the updated QAPP, they provided written documentation of these requirements. Compliance exceptions were subsequently reviewed and, as appropriate, approved by ARC’s quality assurance subcontractor, Environmental Standards, Inc. (ESI). As

previously indicated, the TestAmerica (Irvine, California and Richland, Washington) labs did not initially account for soil moisture content, which has been corrected in this revised DSR. Table 4-1 summarizes the analytes, method detection limits and analytical methods used for the background soils samples. The analyte list, provided in the Work Plan, was based on the occurrence of selected chemicals in the Process Areas of the Site (Brown and Caldwell, 2005).

Table 4-1. Analyses and Methods			
Analyte	Method Detection Limit	Unit	Analytical Method
<i>Metals:</i>			
Aluminum	10	mg/kg	6010B
Antimony	1.0	mg/kg	6020
Arsenic	0.5	mg/kg	6020
Barium	0.5	mg/kg	6020
Beryllium	0.3	mg/kg	6020
Boron	5.0	mg/kg	6010B
Cadmium	0.5	mg/kg	6020
Calcium	15	mg/kg	6010B
Chromium	1.0	mg/kg	6020
Cobalt	0.5	mg/kg	6020
Copper	1.0	mg/kg	6020
Iron	5.0	mg/kg	6010B
Lead	0.5	mg/kg	6020
Magnesium	10	mg/kg	6010B
Manganese	0.5	mg/kg	6020
Mercury	0.02	mg/kg	7471A
Molybdenum	1.0	mg/kg	6020
Nickel	1.0	mg/kg	6020
Potassium	50	mg/kg	6010B
Selenium	1.0	mg/kg	6020
Silver	0.5	mg/kg	6020
Sodium	50	mg/kg	6010B
Thallium	0.5	mg/kg	6020
Vanadium	1.0	mg/kg	6020
Zinc	10	mg/kg	6020
<i>Radiochemicals:</i>			
Uranium (total)	0.5	mg/kg	EPA 6020
Thorium (total)	0.5	mg/kg	EPA 6020
Radium-226	0.1	pCi/g	EPA 903.0
Radium-228	0.1	pCi/g	EPA 904.0

4.2 Quality Assurance and Quality Control Procedures

4.2.1 Quality Assurance Objectives

Quality assurance (QA) objectives are the broad goals for data collection and review. The following quality assurance objectives are described below: precision, accuracy, representativeness, completeness and comparability (PARCC).

- **Precision (P):** Precision is defined as the degree of reproducibility of the measurements under a given set of conditions. Precision is documented on the basis of replicate/duplicate analyses: usually laboratory duplicate, laboratory control sample duplicates or matrix spike duplicates.
- **Accuracy (A):** Accuracy is defined as the bias in a measurement system, and documented on the basis of recovery of surrogates, laboratory control samples and matrix spikes.
- **Representativeness (R):** Representativeness is defined as the degree to which data represent a characteristic of a set of samples. The representativeness of the analytical data is a function of the procedures and carefulness used in procuring and processing the samples. The representativeness can be documented by the relative percent difference between separately procured, but otherwise identical sample aliquots.
- **Completeness (C):** The completeness objective for an analysis is to provide sufficient data of the acceptable quality such that the goals of the analytical project can be achieved. The overall project completeness is expressed as the percentage of planned data that is usable for its intended purpose.
- **Comparability (C):** The comparability objective is to provide analytical data for which the accuracy, precision, representativeness, completeness and detection limit are similar to these quality indicators for data generated by other laboratories for similar samples. The comparability objectives is documented by inter-laboratory studies carried out by regulatory agencies or carried out for specific projects or contracts; and by comparison of periodically generated statements of accuracy, precision and detection limits with those of other laboratories.

These PARCC data quality objectives were evaluated during the data review process. The process of data review also included a completeness check to ensure that all data has been properly loaded into the database that will be used for report generation. Data that failed to meet the data quality assurance objectives for the project have been qualified as to usability and potential low or high bias during the review process. Data was reviewed against the project-

specific limits described in the updated QAPP. The review of soils data by ESI followed the guidance provided in the QAPP and as described in the *National Functional Guidelines for Data Review* (<http://www.epa.gov/superfund/programs/clp/guidance.htm>).

4.2.2 Field Quality Control Samples

Quality control (QC) samples collected during the background investigation included equipment blanks, field blanks, matrix spikes and field duplicates.

Equipment Blanks: Equipment blanks are used to assess the efficiency of field equipment decontamination procedures in preventing cross-contamination between samples. Certified analyte-free reagent water was shipped from the laboratory to the field and poured into/through/over clean (decontaminated) sampling equipment used in the collection of background samples and subsequently collected in prepared sample bottles. The equipment blanks were then shipped back to the laboratories with the associated field samples. Two equipment blanks were collected, less than required by the updated QAPP, because most of the samples were collected using disposable plastic scoops, which do not contribute metals or radiochemicals to the sample. The remaining samples were collected using a geologist's rock pick, which was decontaminated between sample locations, and the appropriate frequency of equipment blanks were collected for these samples.

Boron was detected in one equipment blank, resulting in the qualification as "not detected" of thirteen (13) boron results in the associated background soil samples. The boron in the equipment blank possibly resulted from inadequately decontaminated sampling equipment, possibly resulting in the cross-contamination of boron from one sample to the next. Therefore, analytical results for boron that were detected in background soil samples at levels less than the level found in the equipment blank were qualified as non-detect.

Field Blanks: Field blanks are used to evaluate representativeness by identifying any potential contamination from field procedures or insufficient decontamination. For the background study, one field blank was collected to establish the potential influence of the water media field blank on the analytical results of the soil samples. Because only soil samples were collected, additional field blanks composed of water were not anticipated to compromise the integrity or validity of the analytical results for the samples.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) Samples: MS/MSD samples are investigative samples to which known amounts of analytes are added in the laboratory before extraction/preparation and analysis. The recoveries for spiked compounds can be used to assess how well the method used for analysis recovers target compounds in the

specific sample matrices. The background soils study collected sufficient MS/MSD samples to meet the requirement for one per batch of 20 samples or less.

Field Duplicates: Field duplicates are two samples collected at the same time from adjacent locations and which are submitted to the laboratory as separate samples (i.e., "blind" duplicates). Field duplicate samples can be used to assess the heterogeneity of compounds within the sample matrix and the consistency of the overall sampling effort, including collection, shipping, and analysis; the purpose of submitting them "blind" is to assess the consistency or precision of the laboratory's analytical system. Field duplicate samples were analyzed for the same parameters as the corresponding primary sample. Sufficient field duplicates were collected to meet QAPP requirements.

Table 4-2 lists the QC field samples collected during the background soils investigation.

Table 4-2. Quality Control Field Samples		
Type	Sample ID	Associated Samples
Equipment Blank	BGS-A-2-74E	All samples collected 8/15-8/16
	BGS-A-2-51E	All samples collected 7/30, 8/1-8/2, 8/14
Field Blank	BGS-A-2-67F	All samples
Field Duplicate	BGS-A-1-01S-2	BGS-A-1-01S-1
	BGS-A-1-11D-2	BGS-A-1-11D-1
	BGS-A-1-21S-2	BGS-A-1-21S-1
	BGS-A-1-31D-2	BGS-A-1-31D-1
	BGS-A-2-41S-2	BGS-A-2-41S-1
	BGS-A-2-51D-2	BGS-A-2-51D-1
	BGS-A-2-61S-2	BGS-A-2-61S-1
	BGS-A-2-66D-2	BGS-A-2-66D-1

4.2.3 Data Review Procedures

In accordance with the DQOs established in the Work Plan and the updated QAPP, laboratory results that met all the DQOs have been accepted without qualification. Results associated with QC parameters that did not meet objectives have been qualified as estimated (J flagged), or rejected as unusable for any purpose (R flagged). Data qualified as estimated is considered usable for its intended purpose (the reported result may not be accurate or precise). Data verification was based on the same parameters as validation, except that raw data record reviews and recalculation of results from the raw data were not performed during verification. Validation was performed on 20 percent of the analytical data and verification was performed on the remainder. Data verification/validation elements are presented below (copies of all validation and verification reports are provided in Appendix E):

- Case Narrative
- Chain-of-Custody Documentation
- Summary of Results
- Holding Times
- Method Blank Analysis Results
- Field/Equipment Blank Analysis Results
- Surrogate Standard Percent Recoveries (%R)
- Laboratory Control Samples (LCS) - %R
- Matrix Spikes (MS) - %R
- LCS/LCS Duplicate (LCSD) - Relative Percent Difference (RPD)
- MS/MS Duplicate (MSD) – RPD
- Laboratory Replicate – RPD
- Field Duplicate (FD) – RPD

Qualifiers added to the data are defined below:

- U – Analyte not detected at the detection limit concentration.
- J – Reported value is an estimated concentration.
- UJ – Analyte not detected at an estimated detection limit concentration.
- R – This data was rejected and was not used for any purposes.
- UR – The analyte was not detected. The detection limit is unreliable and may be representative of a false negative. This data was rejected and is not usable for any purpose.

As described above, the September 8, 2008 DSR reported soil sample analytical results that had not been corrected for soil moisture content. The TestAmerica (Irvine, California and Richland, Washington) labs that analyzed the soil samples for most metals and radiochemicals did not perform a moisture analysis, and initially reported the results as wet weight. During a subsequent data verification process in December 2008 for soil samples from the inactive Anaconda evaporation ponds, the analytical results for metals and radiochemicals provided by

these TestAmerica labs were incorrectly reported as wet weight. This review initiated a corrective action process, which resulted in the following actions:

- Because moisture measurements had been performed for background (and evaporation pond) soils sample by the TestAmerica (St. Louis, Missouri) lab for uranium and thorium analyses on the same materials analyzed for other metals and radiochemicals, it was determined that the moisture values reported by the TestAmerica (St. Louis) lab could be applied to the samples analyzed by the other two TestAmerica labs.
- TestAmerica (Irvine and Richland) corrected their results and re-issued the hardcopy laboratory reports and EDDs. The project database was then updated to provide data users with the corrected results. Since the percent moisture for each sample was available and the results were corrected, the Project Chemist and Project Data Validation team determined the data to be valid and useful for inclusion in this revised DSR.

The revised background soils metals data did not need to be re-validated or re-verified (i.e., the validation/verification performed on the original background soils data was acceptable) because the dry-weight correction of the soil sample results did not result in the change of any previously applied validation/verification qualifiers. Specifically, the validation/verification qualifiers applied to the original results with regard to laboratory control sample (LCS), matrix spike/matrix spike duplicate (MS/MSD), and laboratory/field duplicate failures did not change because the dry-weight correction resulted in all positive and ‘not-detected’ results remaining as they were initially reported and only their numerical values were adjusted. In addition, the validation/verification qualifiers applied to the original results with regard to blank contamination did not change because, when the data is evaluated on the basis of blank contamination, this evaluation is done using the wet weight (non-dry-weight corrected) results.

The correction process has not modified the QA/QC results presented in the September 8, 2008 DSR. All analyzed background soil samples had moisture contents below 15 percent, with most soils exhibiting less than three percent moisture. The dry weight corrected values for these samples would increase by a percentage similar to the associated moisture content (e.g., a soil sample with five percent moisture would have a dry weight corrected value that is approximately five percent greater than the wet weight result). Appendix D-3 summarizes the data sets for the wet and dry weight analyses, and compares the analytical results.

4.3 Data Quality Summary and Analytical Completeness

Individual analytical results were qualified during the data verification procedures. The percentage of results that are qualified as estimated or rejected due to QC deficiencies is an indication of the overall data quality for a given analytical method. The following issues described below affected the general quality of the data:

- **Field/Equipment Blank Contamination:** 25 results were qualified as not detected with an estimated detection limit due to field and equipment blank contamination. Compounds affected by these contaminations were boron (24 results were qualified), and barium (1).
- **Method blank Contamination:** 57 results were qualified as not detected with an estimated detection limit due to method blank contamination. Compounds affected by these contaminations were chromium (22 results were qualified), sodium (3) and zinc (32).
- **Relative Percent Difference (RPD):** Eight results from 1 normal/field duplicate pair (copper, manganese, thorium, uranium) were qualified as estimated due to high RPDs.
- **Matrix Spike/Duplicate Recovery:** 546 results (copper, manganese, thorium, uranium) were qualified as estimated due to high or low MS/MSD recoveries.
- **Other:** 15 arsenic results were qualified as estimated due to a low reporting limit (RL) standard recovery.

Table 4-3 provides a summary of the number of results that were qualified by method. Overall the data that is not qualified meets all data quality objectives listed in the updated QAPP. Data qualified as estimated should be evaluated by the data user to determine any usability issues. None of the results have been rejected.

Table 4-3. Analytical Completeness by Method									
Method	Parameter	Samples Analyzed (N+FD)	Analytes per sample	Number of results				Completeness	
				Total	Rejected	Estimated due to QC deficiencies	Estimated due to >MDL but <PQL	Percent usable	Percent quantitative*
E901.1	Radium-226 and 228	148+8	2	312	0	0	0	100%	100%
SW6010B	Metals	148+8	9	1404	0	389	18	100%	72%
SW6020	Metals by ICP/MS	148+8	17	2652	0	252	516	100%	90%
SW7471A	Mercury	148+8	1	156	0	9	9	100%	94%

* Note: Estimations due solely to results <PQL do not affect the calculated completeness
Calculations do not include any required field or laboratory QC samples, except field duplicates.
N = normal environmental samples FD = field duplicate samples

SECTION 5.0

STATISTICAL ANALYSES

This section describes the statistical methodology used to develop background concentration limits (i.e., upper threshold values) for use in the RI/FS process. The approach is the same as used in the September 8, 2008 DSR with the exception that the updated approach does not include duplicate results in the statistical analysis. The objective of the statistical analysis was to calculate background concentration limits that would correspond to background conditions on the Site. The following steps were used for this analysis:

1. The data were compiled in a useful format for data analysis (Section 5.1).
2. The data were characterized using summary statistics and graphs (Section 5.1).
3. Statistical hypothesis tests were conducted to compare concentrations from the two sub-areas. Based on these test results, the decision was made to calculate separate threshold limits for each sub-area. (Section 5.2).
4. Background concentration limits (i.e., threshold values) were calculated for each of the 29 chemicals in both sub-areas. (Section 5.3).
5. The reasonableness of the limits relative to the background data was evaluated graphically. (Section 5.3).

5.1 Data Characterization

The background concentration data are provided as raw data (Excel spreadsheet) in Appendix D-1. The same data, in an expanded format with data qualifiers and sample information, are provided in Appendix D-2. Table 5-1 presents the summary statistics, calculated for each constituent in sub-area A-1, sub-area A-2 and sub-areas A-1 and A-2 combined, and the results of two-sample (i.e., two-group) comparisons. The information in Table 5-1 (e.g., the percent and number of detects) was used to select appropriate statistical methods for conducting the two-sample comparisons and for determining background concentration limits. As stated above, field duplicate samples were not used in any of the following statistical analyses. Data qualified as estimated (i.e., J qualified) were treated the same as nonqualified data.

A preliminary characterization of the data indicated that chemical concentrations appeared to be different for some chemicals between sub-areas, and varied with depth at a number of sample locations. Because human health and ecological risk assessments typically address the upper 10 feet of soil, background concentration limits were not calculated for the two sample depths at each location (both sample depths occur within the upper 10 feet of the soil profile).

To aid in interpretation of the data, individual value plots (IVPs) were constructed for all 29 chemicals (Appendix F). Each concentration value was plotted individually and a random horizontal offset was applied to decrease the overlap between data of the same magnitude. Nondetects are plotted at the RL, and the data are separated by sub-area. Minitab (2004) was used to construct the IVPs.

5.2 Comparison of Concentrations in Sub-area A-1 and Sub-area A-2

As described in Section 3.0 of this report, background soil samples were collected from two sub-areas based on an understanding of bedrock sources for the alluvial fan materials. Two-sample hypothesis testing was conducted to compare soil data from the two sub-areas. The purpose of this analysis was to determine if a statistically significant difference in concentrations between the two sub-areas existed.

Two-sample comparisons were not conducted if the pooled number of detects is less than 16 because EPA statistical guidance recommends a minimum of 8 to 10 detected observations in each data set before applying hypothesis tests (EPA, 2007b, page 24). Therefore, hypothesis tests were not run for antimony, cadmium, selenium, silver and thallium to determine if there was a difference between sub-areas for these analytes.

Table 5-1. Summary Statistics and Results of Two-Sample Comparisons																													
	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Potassium	Radium-226	Radium-228	Selenium	Silver	Sodium	Thallium	Thorium	Uranium	Vanadium	Zinc
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(pCi/g)	(pCi/g)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Sub-area A-1																													
Number of observations	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
Number of detects	74	0	65	74	67	21	0	74	55	74	74	74	74	74	74	6	29	66	74	74	74	1	0	74	7	74	74	74	67
Percent detects	100	0	88	100	91	28	0	100	74	100	100	100	100	100	100	8	39	89	100	100	100	1	0	100	9	100	100	100	91
Minimum detect	4300	n/a	1.8	38	0.21	2.4	n/a	1700	1.8	1.7	4.5	6800	2.4	1500	140	0.013	0.41	2.3	610	0.705	0.796	1.2	n/a	65	0.47	4.1	0.57	8.0	11
Maximum detect	16000	n/a	21	180	1.1	38	n/a	39000	13	14	68	22000	11	6600	550	0.052	3.6	12	3000	2.04	1.84	1.2	n/a	2700	0.76	18.2	3.9	65	58
Number of nondetects	0	74	9	0	7	53	74	0	19	0	0	0	0	0	0	68	45	8	0	0	0	73	74	0	67	0	0	0	7
Percent nondetects	0	100	12	0	9	72	100	0	26	0	0	0	0	0	0	92	61	11	0	0	0	99	100	0	91	0	0	0	9
Minimum nondetect	n/a	0.89	1.8	n/a	0.20	2.1	0.30	n/a	1.8	n/a	n/a	n/a	n/a	n/a	n/a	0.012	0.40	2.3	n/a	n/a	n/a	0.75	0.50	n/a	0.40	n/a	n/a	n/a	27
Maximum nondetect	n/a	0.94	1.8	n/a	0.20	2.2	0.32	n/a	12	n/a	n/a	n/a	n/a	n/a	n/a	0.013	0.42	2.3	n/a	n/a	n/a	0.80	0.54	n/a	0.43	n/a	n/a	n/a	43
Sub-area A-2																													
Number of observations	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
Number of detects	74	0	68	73	69	36	0	74	61	74	74	74	74	74	74	11	47	74	74	74	74	3	0	71	5	74	74	74	50
Percent detects	100	0	92	99	93	49	0	100	82	100	100	100	100	100	100	15	64	100	100	100	100	4	0	96	7	100	100	100	68
Minimum detect	4100	n/a	2.2	35	0.22	2.4	n/a	2100	2.4	2.5	9.2	7300	2	1800	110	0.015	0.41	3.2	450	0.697	0.556	0.80	n/a	93	0.42	3.8	0.63	7.3	11
Maximum detect	28000	n/a	22	520	2.0	27	n/a	79000	19	22	350	28000	19	12000	1300	0.074	4.5	20	6300	2.51	1.77	0.98	n/a	3500	0.84	28.2	5.9	66	66
Number of nondetects	0	74	6	1	5	38	74	0	13	0	0	0	0	0	0	63	27	0	0	0	0	71	74	3	69	0	0	0	24
Percent nondetects	0	100	8	1	7	51	100	0	18	0	0	0	0	0	0	85	36	0	0	0	0	96	100	4	93	0	0	0	32
Minimum nondetect	n/a	0.88	1.8	40	0.20	2.1	0.30	n/a	1.8	n/a	n/a	n/a	n/a	n/a	n/a	0.012	0.39	n/a	n/a	n/a	n/a	0.74	0.49	150	0.39	n/a	n/a	n/a	17
Maximum nondetect	n/a	1.8	1.8	40	0.21	7.8	0.35	n/a	8.4	n/a	n/a	n/a	n/a	n/a	n/a	0.014	0.42	n/a	n/a	n/a	n/a	0.88	0.58	240	0.44	n/a	n/a	n/a	61
Sub-areas A-1 and A-2 Combined																													
Number of observations	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148
Number of detects	148	0	133	147	136	57	0	148	116	148	148	148	148	148	148	17	76	140	148	148	148	4	0	145	12	148	148	148	117
Percent detects	100	0	90	99	92	39	0	100	78	100	100	100	100	100	100	11	51	95	100	100	100	3	0	98	8	100	100	100	79
Minimum detect	4100	n/a	1.8	35	0.21	2.4	n/a	1700	1.8	1.7	4.5	6800	2	1500	110	0.013	0.41	2.3	450	0.697	0.556	0.80	n/a	65	0.42	3.8	0.57	7.3	11
Maximum detect	28000	n/a	22	520	2.0	38	n/a	79000	19	22	350	28000	19	12000	1300	0.074	4.5	20	6300	2.51	1.84	1.2	n/a	3500	0.84	28.2	5.9	66	66
Number of nondetects	0	148	15	1	12	91	148	0	32	0	0	0	0	0	0	131	72	8	0	0	0	144	148	3	136	0	0	0	31
Percent nondetects	0	100	10	1	8	61	100	0	22	0	0	0	0	0	0	89	49	5	0	0	0	97	100	2	92	0	0	0	21
Minimum nondetect	n/a	0.88	1.8	40	0.20	2.1	0.30	n/a	1.8	n/a	n/a	n/a	n/a	n/a	n/a	0.012	0.39	2.3	n/a	n/a	n/a	0.74	0.49	150	0.39	n/a	n/a	n/a	17
Maximum nondetect	n/a	1.8	1.8	40	0.21	7.8	0.35	n/a	12	n/a	n/a	n/a	n/a	n/a	n/a	0.014	0.42	2.3	n/a	n/a	n/a	0.88	0.58	240	0.44	n/a	n/a	n/a	61
2-Sample comparison																													
Method selection																													
Not applicable if pooled detects <16		n/a					n/a															n/a	n/a		n/a				
Gehan if multiple RLs or if combined %NDs >40						Gehan			Gehan							Gehan	Gehan							Gehan					Gehan
WRS in remaining cases	WRS		WRS	WRS	WRS			WRS		WRS	WRS	WRS	WRS	WRS	WRS			WRS	WRS	WRS	WRS					WRS	WRS	WRS	
Assigned ND value for WRS	n/a		0.90	20	0.10			n/a		n/a	n/a	n/a	n/a	n/a	n/a			1.15	n/a	n/a	n/a					n/a	n/a	n/a	
Results																													
Test statistic	4.192		2.562	3.426	1.725	3.067		5.755	4.954	6.172	8.470	6.854	-2.196	6.582	-1.154	1.306	3.449	6.310	2.010	-0.520	-4.048			0.594		0.993	4.013	5.634	1.437
Critical value	1.960		1.960	1.960	1.960	1.960		1.960	1.960	1.960	1.960	1.960	-1.960	1.960	-1.960	1.960	1.960	1.960	1.960	-1.960	-1.960			1.960		1.960	1.960	1.960	1.960
Higher sub-area if significant	A-2	n/a	A-2	A-2	ns	A-2	n/a	A-2	A-2	A-2	A-2	A-2	A-1	A-2	ns	ns	A-2	A-2	A-2	ns	A-1	n/a	n/a	ns	n/a	ns	A-2	A-2	ns

Notes: ns - not significant WRS - Wilcoxon Rank Sum

5.2.1 Method Selection

Two statistical tests were used depending on the percentage of nondetects and the presence of multiple RLs, as described below.

- The Gehan test was used if the pooled percent nondetects is greater than 40 percent or if multiple RLs are present in the data (boron, chromium, mercury, molybdenum, sodium and zinc). This recommendation is consistent with ProUCL (EPA 2007b, page 160).
- The Wilcoxon rank sum (WRS) test was used in the remaining instances (aluminum, arsenic, barium, beryllium, calcium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, radium-226, radium-228, thorium, uranium and vanadium). Table 5-1 summarizes which two-sample approach that was taken for each analyte.

5.2.2 Wilcoxon Rank Sum Test

The Wilcoxon rank sum (WRS) test is a nonparametric hypothesis test that is commonly applied to environmental data. The test can be conducted on data sets with nondetects and does not require data to be normally distributed. The WRS tests were conducted according to procedures explained in Gilbert (1987), using the software program STATISTICA™ (StatSoft, 2004). Results of the analysis are presented in Table 5-1.

To prepare the data for the WRS test, nondetects were set equal to one-half the RL. The assigned values for nondetects, which were always lower than the minimum detected values, are presented in Table 5-1. The WRS test was applied to the beryllium data even though it has two (minimum and maximum) RLs that are similar (i.e., 0.20 and 0.21). The most commonly occurring RL (0.20) was selected and divided by 2 to represent the nondetects for beryllium. Barium has one nondetect value, which was set equal to one-half the RL for purposes of the WRS test and calculation of the background concentration limit.

The procedure for conducting the WRS test is briefly described below:

- The null and alternative hypotheses were expressed as follows:
 - H_0 : the concentrations in sub-area A-1 soils are the same as concentrations in sub-area A-2 soils.
 - H_A : the concentrations in sub-area A-1 soils are not the same as concentrations in sub-area A-2 soils.
- A significance level (α) of 0.05 was selected for the test.
- Sample sizes were indicated as n_1 and n_2 for sub-area A-2 and sub-area A-1, respectively.
- Data from sub-areas A-1 and A-2 were combined and ranked.
- The test statistic, W_{RS} , was calculated as the sum of ranks for the sub-area A-2 data.
- Z_{RS} , which is the large sample statistic adjusted for ties, was calculated from W_{RS} as shown in equation 18.9 in Gilbert (1987). (A positive value for Z_{RS} indicates that sub-area A-2 concentrations are larger than sub-area A-1 concentrations, although the difference may not be significant.)
- $Z_{1 - \alpha/2}$ was obtained from Table A-1 in Gilbert (1987), which gives Z values for varying levels of α .
- H_0 was rejected and H_A was accepted if $Z_{RS} \leq -Z_{1 - \alpha/2}$ or $Z_{RS} \geq Z_{1 - \alpha/2}$.

5.2.3 Gehan Test

The Gehan test is a nonparametric hypothesis test that is appropriate for comparing two data sets when one or both data sets contains nondetect values with different RLs. Because the Gehan test does not require the data to have a specific distribution, no distributional testing was conducted before applying the test. Calculations were performed according to procedures presented in NAVFAC (2002, page 78-86) using the statistical software program Splus (Insightful, 2005). Results of the analysis are presented in Table 5-1. A brief description of how the Gehan test was applied to the background soils data is provided below:

- The null and alternative hypotheses were expressed as follows:
 - H_0 : the concentrations in sub-area A-1 soils are the same as concentrations in sub-area A-2 soils.
 - H_A : the concentrations in sub-area A-1 soils are not the same as concentrations in sub-area A-2 soils.
- A significance level (α) of 0.05 was selected for the test.
- Sample sizes were designated as “ m ” and “ n ” for sub-area A-1 and sub-area A-2 data, respectively.

- Data from sub-areas A-1 and A-2 were combined and ranked according to the example given in Box 4-12 of NAVFAC (2002, page 85). The ranks were designated as R_1, R_2, \dots, R_N , for the N ordered data values.
- The Gehan statistic was computed according to the following formula (a positive value for G indicates that sub-area A-2 concentrations are larger than sub-area A-1 concentrations, although the difference may not be significant):

$$G = \frac{\sum_{i=1}^N h_i a(R_i)}{\{mn \sum_{i=1}^N [a(R_i)]^2 / [N(N-1)]\}^{\frac{1}{2}}}$$

where: h_i = 1 if the i th datum is from the sub-area A-2 population
 = 0 if the i th datum is from the sub-area A-1 population
 N = $n + m$
 $a(R_i)$ = $2 R_i - N - 1$, where i is successively set equal to 1, 2, ..., N .

- The critical value of Z ($Z_{1 - \alpha/2}$) was obtained from Table C-1 in NAVFAC (2002, page 147).
- H_0 was rejected and H_A was accepted if $G \leq -Z_{1 - \alpha/2}$ or $G \geq Z_{1 - \alpha/2}$.

5.2.4 Results of Two-Sample Comparisons

Two-sample comparison tests were conducted on 24 of the 29 background chemicals. Concentrations were found to be significantly higher in sub-area A-2 than sub-area A-1 for 15 of the analytes, and significantly higher in sub-area A-1 than sub-area A-2 for two analytes. Tests for the remaining seven chemicals indicated that the differences were not significant. These results indicated that the soils in the two sub-areas exhibit different chemical characteristics, and that separate background concentration limits should be developed for each sub-area.

5.3 Development of Background Concentration Limits

For chemicals with a sufficient number of detected values, background concentration limits (i.e., upper threshold values) were set equal to the 90 percent Chebyshev upper prediction limit (UPL)

(see Section 5.3.2), or the highest RL if fewer than three detected values in the data set. A two-step process was used to develop the background concentrations limits based on the UPL: 1) estimation of the mean and standard deviation; and 2) calculation of the Chebyshev UPL, which requires the estimates of the mean and standard deviation. Background concentration limits and associated statistics are presented in Table 5-2, and proposed background concentration limits for each sub-area are summarized in Table 5-3.

5.3.1 Estimation of the Mean and Standard Deviation

Estimate of the mean and standard deviation, which are required for the Chebyshev UPL, were determined in two ways: (1) if the data do not contain nondetects, the mean and standard deviation were calculated using standard equations in Excel, (2) if the data do contain nondetect measurements, the Kaplan-Meier method was used to estimate the mean and standard deviation. Because barium in sub-area A-2 has only one nondetect value, the nondetect was set equal to one-half the RL and Excel was used to estimate the mean and standard deviation.

The Kaplan-Meier method is used to estimate summary statistics (e.g., the mean and standard deviation) for data with nondetect measurements. In the past, the most commonly used approach for estimating summary statistics was to substitute one half the RL for nondetects, and use standard equations such as those presented in Excel. In the latest version of ProUCL, the recommended approach is the Kaplan-Meier estimation method. This method has been used extensively in the field of survival analysis where right censored data (i.e., “greater-thans”) are encountered. The Kaplan-Meier method has recently been adapted to environmental data sets, which often contain left censored data (i.e., “less-thans”). The method is particularly practical for environmental data because it can handle data sets with multiple detection limits. Helsel (2005) and EPA (2007b) recommend the use of the Kaplan-Meier estimation method for environmental data. Further details are available in Kaplan and Meier (1958), Helsel (2005), and EPA (2007b).

Calculations were performed using ProUCL (EPA, 2007b). ProUCL is a statistical software package that was originally developed to calculate exposure point concentrations for use in risk assessment. The most current version (4.00.02) is broader in scope than previous versions

because it includes methods for analyzing censored data (e.g., the Kaplan-Meier method), and methods for evaluating background data (e.g., Chebyshev method for upper prediction limits). ProUCL was developed for the EPA and is widely used by environmental professionals.

Kaplan-Meier estimates of the mean and standard deviation were calculated for 9 of the 29 data sets in sub-area A-1, and 10 of the 29 data sets in sub-area A-2. The mean and standard deviation were not estimated for data sets with fewer than three detected values. All estimates of the mean and standard deviation are presented in Table 5-2.

5.3.2 Upper Prediction Limits by the Chebyshev Method

Chebyshev UPLs are one of several ways to develop upper threshold values. Examples of other methods are upper tolerance limits, upper percentiles, and the maximum concentration. UPLs provide a specified probability (e.g., 90 percent) that a single measurement from the Site will produce a value higher than the UPL if the two distributions are the same (i.e., a false positive). Therefore, for a 90 percent UPL, there is a 10 percent chance that the UPL could be exceeded by single Site value even if there is no contamination (Gibbons 1994, page 11).

The Chebyshev method for calculating upper prediction limits was used for this analysis. This method was selected because it produces realistic estimates of the UPL for a wide variety of data sets. Also, because this is a nonparametric method, it can be used on all data sets regardless of their distribution. As recommended by EPA (2007b), 90 percent Chebyshev UPLs were calculated. The equation for calculating the Chebyshev UPL is given below (EPA, 2007b):

$$UPL = \bar{x} + [\sqrt{((1/\alpha) - 1) * (1 + 1/n)}]s_x$$

where \bar{x} is the mean and s_x is the standard deviation.

As stated previously, the mean and standard deviation were calculated using standard equations in Excel for data sets with no nondetects. Otherwise, the Kaplan-Meier method was used.

5.3.3 Evaluation of Background Concentration Limits

Background concentration limits for sub-areas A-1 and A-2 are shown on the individual value plots (IVPs) in Figure F1. These graphs were examined to evaluate the reasonableness of the limits relative to the background concentration data. All of the limits appear to represent reasonable estimates of background conditions. Table 5-2 provides a summary of the statistical analysis and resulting background concentration limits, and Table 5-3 summarizes the proposed background concentration limits for the soils from sub-areas A-1 and A-2 to be used for specific Site OUs.

Table 5-2. Background Statistics and Concentration Limits																													
	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Potassium	Radium-226	Radium-228	Selenium	Silver	Sodium	Thallium	Thorium	Uranium	Vanadium	Zinc
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(pCi/g)	(pCi/g)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Sub-area A1																													
Number of observations	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
Number of detects	74	0	65	74	67	21	0	74	55	74	74	74	74	74	74	6	29	66	74	74	74	1	0	74	7	74	74	74	67
Percent detects	100	0	88	100	91	28	0	100	74	100	100	100	100	100	100	8	39	89	100	100	100	1	0	100	9	100	100	100	91
Estimation method for mean and standard deviation	arithmetic	n/a	KM	arithmetic	KM	KM	n/a	arithmetic	KM	arithmetic	arithmetic	arithmetic	arithmetic	arithmetic	arithmetic	KM	KM	KM	arithmetic	arithmetic	arithmetic	n/a	n/a	arithmetic	KM	arithmetic	arithmetic	arithmetic	KM
Mean	8066	n/a	4.1	83	0.44	4.8	n/a	5320	4.4	4.3	17	10359	5.9	2780	248	0.014	0.54	4.7	1472	1.23	1.38	n/a	n/a	513	0.48	7.7	1.2	24	26
Standard deviation	2778	n/a	3.0	29	0.19	6.2	n/a	5726	2.3	2.4	14	3027	1.7	1170	92	0.0055	0.40	2.3	627	0.269	0.286	n/a	n/a	523	0.044	2.3	0.54	11	12
Method for determining background concentration limit	90% UPL	RL	90% UPL	90% UPL	90% UPL	90% UPL	RL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	RL	RL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL
Background concentration limit	16455	0.94	13	171	1.0	24	0.32	22614	11	12	58	19502	11	6314	526	0.031	1.7	12	3365	2.04	2.24	0.80	0.54	2093	0.61	15	2.9	57	61
Sub-area A2																													
Number of observations	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
Number of detects	74	0	68	73	69	36	0	74	61	74	74	74	74	74	74	11	47	74	74	74	74	3	0	71	5	74	74	74	50
Percent detects	100	0	92	99	93	49	0	100	82	100	100	100	100	100	100	15	64	100	100	100	100	4	0	96	7	100	100	100	68
Estimation method for mean and standard deviation	arithmetic	n/a	KM	arithmetic*	KM	KM	n/a	arithmetic	KM	arithmetic	arithmetic	arithmetic	arithmetic	arithmetic	arithmetic	KM	KM	arithmetic	arithmetic	arithmetic	arithmetic	KM	n/a	KM	KM	arithmetic	arithmetic	arithmetic	KM
Mean	10908	n/a	5.6	111	0.50	5.7	n/a	11364	7.3	6.4	78	14891	5.4	4435	251	0.018	0.90	7.8	1860	1.26	1.16	0.80	n/a	584	0.43	8.3	1.6	33	29
Standard deviation	4810	n/a	3.9	66	0.26	5.1	n/a	11675	4.0	2.7	68	4494	2.4	1806	159	0.011	0.80	3.4	1116	0.390	0.320	0.022	n/a	604	0.054	3.5	0.83	11	11
Method for determining background concentration limit	90% UPL	RL	90% UPL	90% UPL	90% UPL	90% UPL	RL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	RL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL	90% UPL
Background concentration limit	25436	1.8	17	310	1.3	21	0.35	46625	19	15	285	28465	13	9889	729	0.050	3.3	18	5229	2.44	2.13	0.87	0.58	2407	0.60	19	4.1	65	62

Notes:
* The single nondetect was set equal to 1/2 RL.
KM - Kaplan-Meier
UPL - upper prediction limit
RL – Reporting Limit

Table 5-3. Summary of Background Concentration Limits			
Constituent	Units	Sub-area A-1	Sub-area A-2
Aluminum	(mg/kg)	16,455	25,436
Antimony	(mg/kg)	0.94	1.8
Arsenic	(mg/kg)	13	17
Barium	(mg/kg)	171	310
Beryllium	(mg/kg)	1.0	1.3
Boron	(mg/kg)	24	21
Cadmium	(mg/kg)	0.32	0.35
Calcium	(mg/kg)	22,614	46,625
Chromium	(mg/kg)	11	19
Cobalt	(mg/kg)	12	15
Copper	(mg/kg)	58	285
Iron	(mg/kg)	19,502	28,465
Lead	(mg/kg)	11	13
Magnesium	(mg/kg)	6,314	9,889
Manganese	(mg/kg)	526	729
Mercury	(mg/kg)	0.031	0.050
Molybdenum	(mg/kg)	1.7	3.3
Nickel	(mg/kg)	12	18
Potassium	(mg/kg)	3,365	5,229
Radium-226	(pCi/g)	2.04	2.44
Radium-228	(pCi/g)	2.24	2.13
Selenium	(mg/kg)	0.80	0.87
Silver	(mg/kg)	0.54	0.58
Sodium	(mg/kg)	2,093	2,407
Thallium	(mg/kg)	0.61	0.60
Thorium	(mg/kg)	15	19
Uranium	(mg/kg)	2.9	4.1
Vanadium	(mg/kg)	57	65
Zinc	(mg/kg)	61	62

SECTION 6.0

DATA INTERPRETATION AND USE

The following guidance documents describe how background soils data may be used at the Site:

- *Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites*; EPA/540/S-96/500; December 1995
- *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*; EPA 540-R-01-003; OSWER 9285.7-41; September 2002
- *Role of Background in the CERCLA Cleanup Program*; EPA, OSWER 9285.6-07P; April 26, 2002
- *Procedural Guidance for Statistically Analyzing Environmental Background Data*; Prepared by: Naval Facilities Engineering Command; September 1998
- *Handbook for Statistical Analysis of Environmental Background Data*; Prepared by: Naval Facilities Engineering Command; (July 1999a)
- *Guidance for Environmental Background Analysis, Volume I: Soil*; Prepared by: Naval Facilities Engineering Command; (July 1999b)

6.1 Geologic Interpretation

Interpretation of the background soils data, and statistical analysis of the data, must be based on the geologic context of the reference areas and sampling design described in Sections 2.0 and 3.0 of this DSR, respectively. Naturally occurring chemicals in soils are sourced from rock-forming minerals. Soil is formed when rocks and their component minerals are broken down by physical and chemical weathering. Physical weathering is the mechanical disintegration of rock by natural forces such as rain, wind and gravity. Chemical weathering is the most important process in soil formation and is the mobilization of the chemical elements of rock-forming minerals. This process results in the physical disintegration of the rock, formation of new (secondary) minerals, and changes in the overall chemical composition. Physical and chemical weathering of rocks and minerals creates soils with distinctive geochemical signatures, which reflect the mineralogy of the up-gradient bedrock source materials.

Source Materials

The distribution of metals and radiochemicals in native soils depends primarily on the mineral composition of the source (i.e., parent) rock from which the soil was derived. Therefore, the natural geochemical relationships that exist in the source rock are usually reflected in nearby or down-gradient soils. Additionally, concentrations of naturally occurring chemicals usually are related closely to soil type. Soils that contain abundant gravel and coarse sands tend to have geochemical characteristics more closely related to the parent rock. Finer soils, with abundant silt and clay, have generally been subject to a higher degree of chemical and physical weathering and, therefore, will exhibit greater differences relative to the source rock. Clay and silt can also act as a barrier to mobilized solutes and, therefore, can have higher concentrations of mobile constituents as they tend to accumulate in these layers.

The reference areas for the soils background investigation at the Site include the two sub-areas described in Section 3.0, defined on the basis of the up-gradient bedrock source materials exposed in the Singatse Range. The two sub-areas are separated by the Mickey Pass Canyon drainage, which results in a natural boundary between the two sub-areas. Although obscured by surface disturbances, this boundary likely extends through the Site and terminates against the fluvial sedimentary deposits of the Walker River (Figure 2-1).

Sub-Area A-1

Sub-area A-1 covers approximately 1,200 acres and consists of alluvial fan deposits and soils derived predominantly from the Mickey Pass Tuff and the Singatse Tuff. The Mickey Pass and Singatse Tuffs are Tertiary aged (i.e., approximately 27 to 27.5 million years in age) volcanic flows, which originated from an unknown volcanic source thought to be 200 km to the east. They are described by Proffett and Dilles (1984) as a rhyolite tuff or a quartz latite ash flow tuff which is defined as a crystal rich rock with high silica content (70-75 percent) with predominantly crystals of feldspar and biotite. The thickest member of the Mickey Pass Tuff has been measured at thicknesses up to 2,660 feet and the Singatse Tuff is 700 to 1,200 feet thick, although the thickness in the vicinity of the Yerington Mine is not known.

These volcanic units are typically not mineralized or subjected to hydrothermal alteration that would result in increased chemical concentrations associated with porphyry copper deposits. However, the chemical weathering of feldspars in these volcanic units can release aluminum, calcium, potassium, sodium and other minor chemical components to soils.

Sub-Area A-2

Sub-area A-2 covers an area of approximately 900 acres composed of alluvial fan deposits and soils predominantly derived from a mixture of Mickey Pass tuff (approximately 40 percent) and granitic rocks of the Yerington Batholith (approximately 40 percent). Additional source rocks in this sub-area include andesitic volcanic flows (approximately 10 percent) and limestone (approximately 10 percent). Sub-area A-2 is located west and southwest (topographically up-gradient) of the Process Areas, open pit and waste rock areas of the Site.

The granitic rocks of the Yerington Batholith are Jurassic aged (i.e., approximately 169 million years in age), and formed as an intrusive plug which was subsequently uncovered through basin-and-range faulting, mountain block uplift and erosion. The granitic rocks have been subject to large scale alteration and mineralization as evidenced by the several large known porphyry copper deposits in the district, including the Yerington orebody. Additionally, localized skarn mineralization has occurred in the older limestone rocks where they are in contact with the granitic rock (e.g., as observed at the Bluestone Mine).

Much of the source rock in sub-area A-2 is known to be mineralized and numerous prospect pits and mining operations have occurred in the outcrops in this source area since the late 1800s. Generally, the rocks within this sub-area contain elevated concentrations of base metals, and the soils derived from the mineralized granitic rocks are also expected to have higher concentrations than in sub-area A-1. The analytical results of soil samples collected from sub-area A-2 demonstrate the influence of mineralized source rocks, as shown in the statistical summaries and individual value plots (IVPs; Appendix F), with significantly greater copper concentrations in sub-area A-2 than in sub-area A-1.

Soil Types

Based on SCS mapped soils (Figure 2-2 and Appendix C), the predominant soil types that occur in the area of the Site, including the background soils reference area, are gravelly sandy loams of the Rawe (SCS Unit 551), Rawe-Malpais association (Unit 553), and Malpais (Unit 751) series. These types: 1) consist of very deep, well drained, slow to moderately permeable soils formed on smooth or dissected alluvial fans derived from igneous and granitic rocks or mixed rock sources; 2) are neutral to moderately alkaline in the shallow horizons and can be strongly alkaline in the deeper horizon with caliche commonly coating the rock fragments (SCS, 1984); and 3) are very similar to each other in physical characteristics such as soil depth, particle size distribution, permeability and organic content with the primary difference being the source rock (i.e., chemical differences were not expected and were not observed based on the mapped soil units).

An additional soil type, the Singatse (Unit 631), is a very gravelly sandy loam, occurs in the eastern portion of the Site and underlies a portion of the sulfide tailings (Figure 2-2). Unit 631 is composed of colluvium with abundant pebble-sized rock fragments derived from the same bedrock source materials (i.e., volcanic and mineralized granitic rocks) identified in sub-area A-2 (Figure 2-1). Because of the limited thickness of the colluvium, 10 to 20 inches, this soil type was initially excluded from the background soils sampling program due to the inability to collect two samples from each location at 6-12 inches and 2-3 feet bgs. Soil types not present in the two sub-areas would be characterized (i.e., supplemental background soils investigations) in conjunction with future remedial investigations of Site OUs (e.g., OU-4 and OU-7).

6.2 Comparison of Sub-Area Data

Background concentration limits, calculated as the 90 percent Chebyshev UPL, are shown on the IVPs provided in Appendix F. These graphic representations of the background soils data allow for an easy comparison of the analytical results from the two sub-areas. For example, because of the mineralized character of the source rocks observed in sub-area A-2, it is not surprising to see the relative differences in copper analytical results and associated background concentration limit statistic (Appendix F, page 6).

The copper background concentration limit for sub-area A-2 is approximately 4.9 times that of sub-area A-1 (285 mg/kg vs. 58 mg/kg). Copper represents the most extreme example. Other metals associated with mineralization and the alteration halo of an economic porphyry copper deposit occur at greater concentrations in sub-area A-2 than sub-area A-1 (as used below, the term ‘limit’ refers to background concentration limit):

- Aluminum (sub-area A-2 limit = 25,436 mg/kg vs. sub-area A-1 limit = 16,455 mg/kg)
- Barium (sub-area A-2 limit = 310 mg/kg vs. sub-area A-1 limit = 171 mg/kg)
- Chromium (sub-area A-2 limit = 19 mg/kg vs. sub-area A-1 limit = 11 mg/kg)
- Cobalt (sub-area A-2 limit = 15 mg/kg vs. sub-area A-1 limit = 12 mg/kg)
- Iron (sub-area A-2 limit = 28,465 mg/kg vs. sub-area A-1 limit = 19,502 mg/kg)
- Magnesium (sub-area A-2 limit = 9,889 mg/kg vs. sub-area A-1 limit = 6,314 mg/kg)
- Molybdenum (sub-area A-2 limit = 3.3 mg/kg vs. sub-area A-1 limit = 1.7 mg/kg)
- Nickel (sub-area A-2 limit = 18 mg/kg vs. sub-area A-1 limit = 12 mg/kg)
- Selenium (sub-area A-2 limit = 0.87 mg/kg vs. sub-area A-1 limit = 0.80 mg/kg)
- Thorium (sub-area A-2 limit = 19 mg/kg vs. sub-area A-1 limit = 15 mg/kg)
- Uranium (sub-area A-2 limit = 4.1 mg/kg vs. sub-area A-1 limit = 2.9 mg/kg)

The selenium comparison presented above should be considered with the following limitations: 1) sub-area A-1 had only one detect (1 out of 74), and the background concentration limit was set to the highest RL of 80mg/kg; 2) sub-area A-2 had only three detects; and 3) the two-sample comparison was not performed for selenium due to limited number of detects (less than 16 from both sub-areas). Two metals commonly associated with precious metals mineralization and, in general, volcanic rocks in western Nevada (e.g., Shacklette and Boerngen, 1984), exhibit similar differences:

- Arsenic (sub-area A-2 limit = 17 mg/kg vs. sub-area A-1 limit = 13 mg/kg)
- Mercury (sub-area A-2 limit = 0.050 mg/kg vs. sub-area A-1 limit = 0.031 mg/kg)

Elevated concentrations of arsenic and mercury are not interpreted to be genetically linked to the formation of the Yerington ore body or to historic mineral processing operations at the Site. The

calculated background concentration limits for two radiochemicals observed on the Site as TENORM (radium-226 and -228) also exhibit differences between the two sub-areas:

- Radium-226 (sub-area A-2 limit = 2.44 pCi/g vs. sub-area A-1 limit = 2.04 pCi/g)
- Radium-228 (sub-area A-2 limit = 2.13 pCi/g vs. sub-area A-1 limit = 2.24 pCi/g)

6.3 Use of Proposed Background Concentration Limits

Based on the analytical results of the soil samples, and the statistical analysis of these data, the background concentration limits presented in Table 5-3 are proposed for use at the Site to support the RI/FS process. The chemical data, and the statistical analysis of the data described in Section 5.0, indicate that the concentrations are sufficiently different between the two sub-areas (17 out of 24 comparisons showed statistically significant differences in concentrations between the two sub-areas) to warrant separate background concentration limits for each sub-area. ARC proposes that:

- the limits developed for sub-area A-1 be used for OU-6 (Oxide Tailings)
- the limits developed for sub-area A-2 be used for OU-2 (Pit Lake), OU-3 (Process Areas) and OU-5 (Waste Rock areas)

A visual comparison of Figures 1-2 and 2-2 indicates that the geometry of SCS soil types, including those associated with sub-areas A-1 and A-2, is uncertain beneath OU-4, which includes the Evaporation Ponds and Sulfide Tailings. In addition, the Wabuska Drain (OU-7) is not represented by the background soils data presented in this DSR, and the majority of Arimetco Facilities (OU-8) appear to occur on sub-area A-1 and A-2 soils. Therefore, ARC proposes to meet with EPA to develop an approach for characterizing other background soils and, if possible, developing background concentration limits for all Site OUs.

The characterization of background soils will: 1) provide the basis for a comparison of Site soils to determine areas impacted by historic mine operations; 2) support the development of remedial guidelines to manage impacted Site materials (i.e., impacted soils, tailings, waste rock, evaporation pond residues, etc.); and 3) support future risk assessment activities for the Site. Per

EPA guidance, ARC anticipates that the background soils data presented in this DSR, and additional data to be collected during remedial investigations and from other background reference areas, will support the following RI/FS objectives:

- Metals and radiochemicals that may have been released at the Site will be clearly identified to ensure that the RI/FS process is focused on the investigation of Anaconda releases;
- The risk associated with background concentrations of inorganic chemicals will be calculated in the human health and ecological risk assessments to determine the difference between the risk associated with background and any releases from the Site (i.e., the ‘incremental risk’); and
- Remedial action objectives (RAOs), such as EPA-approved presumptive remedies and appropriate institutional controls, will be limited only to chemicals with concentrations that are elevated above background as a result of a Site-related release.

ARC recognizes that, in the case of some chemicals, human health or ecological risks may be associated with chemical concentrations in Site soils within the range of background soils. Chemicals screened out due to background considerations will be compared to the appropriate risk-based screening criteria, and the results will be documented in the risk characterization sections of the human health and ecological risk assessment reports.

Comparisons With Site Soils

Background concentration limits are expected to be used as a tool in the evaluation of soils data collected from the Site during future remedial investigation to determine if Site soils have been impacted by mining and processing activities, which may have resulted in metal and radiochemical concentrations above naturally occurring levels. Background soil concentrations may be used to establish investigation screening levels in conjunction with, or in the absence of, other appropriate screening levels. These include: 1) EPA Region 9 preliminary remediation goals (PRGs); 2) recently established, and more current, regional screening levels (RSLs; EPA, 2008), which are human health risk-based screening criteria that have been combined from three EPA Regions (Regions 3, 6 and 9); and 3) ecological soil screening levels (e.g., Eco-SSLs; EPA, 2005b). Background concentration can be used in the development of field sampling and

analysis plans and establishing criteria for the collection of delineation samples. Data users will evaluate the comparability of the data sets intended for comparison to background soils to ensure the soil types and analytical methods are consistent between each group.

Development of Remediation Guidelines

The determination of remediation activities and goals may be affected by background soil concentrations such that it would not be feasible to remediate a site to levels lower than naturally occurring concentrations. For example, cleanup goals at the Site are not anticipated to be set at levels below background concentration limits developed for individual OUs.

Risk Assessments

For human health and ecological risk assessment activities at the Site, EPA policy recommends retaining chemicals that exceed risk-based screening concentrations and evaluating the relative contribution of background concentrations in the risk characterization at the end of the risk assessment. Specifically, for screening level ecological risk assessments (SLERAs) to be performed for the Site OUs, background concentration limits may be used as follows:

- Direct comparisons with national Eco-SSL background values;
- Direct comparisons with OU-specific soil concentrations;
- Calculation of incremental risk to distinguish the relative contribution of background to overall risk associated with the Site.

SECTION 7.0 REFERENCES

- Brown and Caldwell, 2005a, *Data Summary Report for Process Areas Groundwater Conditions*, prepared for the Atlantic Richfield Company. September 23, 2005.
- Brown and Caldwell, 2005b, *Data Summary Report for Process Areas Soil Characterization*, prepared for the Atlantic Richfield Company. November 1, 2005.
- Brown and Caldwell, 2006, *Background Soils Work Plan*, prepared for the Atlantic Richfield Company. August 2, 2006.
- Brown and Caldwell, 2008, *Air Quality Monitoring Program Data Summary Report. Yerington Mine Site*, prepared for the Atlantic Richfield Company. May 29, 2008.
- Environmental Standards, Inc. and Brown and Caldwell, 2007, *Quality Assurance Project Plan, Yerington Mine Site, Revision 2*, prepared for the Atlantic Richfield Company.
- EPA, 1994, *Guidance for the Data Quality Objectives Process*. EPA QA/G4. Office of Research and Development, Washington, D.C. EPA/600/R-96/055.
- EPA, 1995, *Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites*. EPA/540/S-96/500, December 1995
- EPA, 2002a, *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*. Office of Emergency and Remedial Response, Washington D.C. EPA/540/R-01/003.
- EPA, 2002b, *Role of Background in the CERCLA Cleanup Program*. EPA OSWER 9285.6-07P, Memorandum dated April 26, 2002.
- EPA, 2005a, *Anaconda/Yerington Mine Site Unilateral Administrative Order for Initial Response Activities EPA Docket No. 9-2005-0011*.
- EPA, 200b, *Guidance for Developing Ecological Soil Screening Levels*. Washington, DC, EPA OSWER 9285.7-55. February 2005.
- EPA, 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process*. QA/G-4. Office of Environmental Information, Washington DC. EPA/240/B-06/001.
- EPA, 2007a, Administrative Order for the Remedial Investigation and Feasibility Study. In the matter of Anaconda / Yerington Mine Site, Yerington, Lyon County, Nevada. Atlantic

- Richfield, Respondent. EPA Region 9, Docket No. 9-2007-0005. Including Attachment A: Scope of Work for the Remedial Investigations / Feasibility Studies Continued Response Action. January.
- EPA, 2007b, ProUCL Version 4.0 Technical Guide. Authored by Anita Singh, Lockheed Martin Environmental Services, and Ashok Singh, University of Nevada, Las Vegas. Document number EPA/600/R-07/041, April 2007.
- EPA, 2008, http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.
- Gibbons, R.D. 1994, Statistical Methods for Groundwater Monitoring. John Wiley & Sons, Inc., New York, NY, 286 pages.
- Gilbert, R.O. 1987, Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold Company, New York, NY.
- Helsel, D.R. 2005, Nondetects and Data Analysis. John Wiley and Sons, New York, NY, 250 pages.
- Insightful Corp., 2005, S-PLUS for Windows, Professional Developer. Insightful Corp., 1700 Westlake Ave. North, Suite 500, Seattle, WA 98109-3044, phone: (206) 283-8802, WEB: <http://www.insightful.com>. Release 7.0.
- Kaplan, E.L. and Meier, O. 1958, *Nonparametric Estimation from Incomplete Observations*. Journal of the American Statistical Association, Vol. 53. 457-481.
- Minitab, Inc. 2004, MINITAB for Windows. Minitab, Inc., 3081 Enterprise Drive, State College, PA 16801-3008, phone: (814) 238-3280, WEB: <http://www.minitab.com>. Release 14.
- NAVFAC. 1998, *Procedural Guidance for Statistically Analyzing Environmental Background Data*. Naval Facilities Engineering Command, Washington, D.C. September 1998.
- NAVFAC, 1999a, *Handbook for Statistical Analysis of Environmental Background Data*. Naval Facilities Engineering Command, Washington, D.C. July 1999.
- NAVFAC, 1999b, *Guidance for Environmental Background Analysis*, Volume I: Soil. Naval Facilities Engineering Command, July 1999
- NAVFAC, 2002, *Guidance for Environmental Background Analysis, Volume 1: Soil*. NFESC User's Guide, UG-2049-ENV. Naval Facilities Engineering Command, Washington, D.C. April 2002.
- Proffett, J.M., Jr., and Dilles, J.H., 1984, Geologic Map of the Yerington District, Nevada. Nevada Bureau of Mines and Geology, Map 77.

- SCS, 1984, *Soil Survey of Lyon County Area, Nevada*, Soil Conservation Service, U.S. Department of Agriculture.
- Schacklette, H.T. and Boerngen, J.G., 1984, *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States*. U.S. Geological Survey, Professional Paper 1270.
- Seitz, H.R., A.S. Van Denburgh, and La Carma, R.J., 1982, *Ground-Water Quality Downgradient from Copper-One Milling Wastes at Weed Heights, Lyon County, Nevada*. U.S. Geological Survey, Open-File Report 80-1217.
- StatSoft, Inc. 2004, STATISTICA for Windows – data analysis software system. StatSoft, Inc., 2300 East 14th Street, Tulsa, OK 74104, phone: (918) 749-1119, fax: (918) 749-2217, email: info@statsoft.com, WEB: <http://www.statsoft.com>. Version 7.1.
- WRCC, 2007, Yerington, Nevada (269229): Period NCDC 1971-2000 Monthly Normals. Western Regional Climate Center. <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nv9229>.